NASA Langley's

Subsurface Imaging of Nanocomposites

Via resonant difference-frequency atomic force ultrasonic microscopy (RDF-AFUM)

NASA Langley has developed a new non-destructive method for characterizing nanomaterials. Based on modified atomic force ultrasonic microscopy (AFUM) methods, the technology allows imaging and quantifying of material properties at the surface and subsurface levels. NASA developed the technology to reveal the orientation of nanotubes within a composite structure. The technology offers the ability to determine subsurface characteristics without destroying the nanomaterial structure. The method is widely applicable for basic nanomaterials characterization, including distribution and orientation of particles in a nanocomposite, localized elastic constants and changes in elastic constants, adhesive surface properties, sound velocity, and material damping coefficient.

Benefits

- Non-destructive: Previous methods require destructive sampling
- Ubiquitous: Enables a wide range of materials characterization for nanomaterials
- Elegant: Design is based on modifications to commercially available AFUM hardware

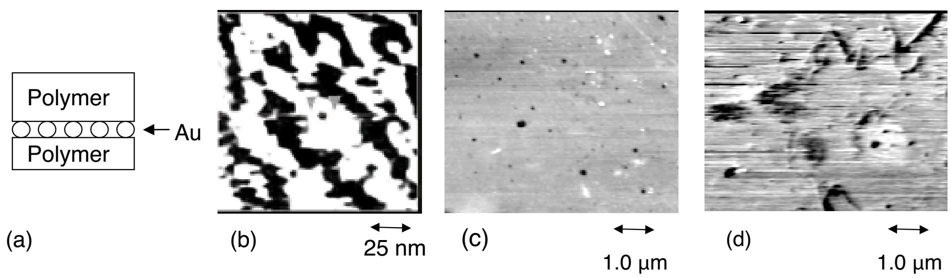
partnership opportunity

Langley Research Center

The Technology

The manufacturing of nanocomposites produced by the embedding of nanostructural constituents into matrix materials has placed increased demands on the development of new measurement methods and techniques to assess the microstructure physical property relationships of such materials. Although a number of techniques are available for near-surface characterization, NASA's new method allows assessment of deeper (subsurface) features at the nanoscale.

This new scanning probe microscope methodology is called resonant difference-frequency atomic force ultrasonic microscopy (RDF-AFUM). It employs an ultrasonic wave launched from the bottom of a sample while the cantilever of an atomic force microscope engages the sample top surface. The cantilever is driven at a frequency differing from the ultrasonic frequency by one of the contact resonance frequencies of the cantilever. The nonlinear mixing of the oscillating cantilever and the ultrasonic wave at the sample surface generates difference-frequency oscillations at the cantilever contact resonance. The resonance-enhanced difference-frequency signals are used to create amplitude and phase-generated images of nanoscale near-surface and subsurface features.

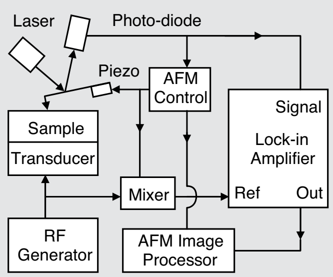


(a) Depiction of specimen vertical cross-section
(b) RDF-AFUM phase image of sample. An RDF-AFUM micrograph of a 12.7-µm thick film of LaRC-CP2 containing a monolayer of gold nanoparticles embedded 7 µm below the specimen surface reveals the occurrence of contiguous amorphous and crystalline phases within the bulk of the polymer and a preferential growth of the crystalline phase in the vicinity of the gold nanoparticles.
(c) Conventional atomic force microscopy (AFM) image
(d) RDF-AFUM phase image of same. An RDF-AFUM micrograph of LaRC-CP2 film containing randomly dispersed carbon nanotubes reveals the growth of an interphase region at certain nanotube-polymer interfaces.

Applications

The technology offers wide-ranging market applications, including:

- Aerospace – functional nanocomposites for structures
- Biomedical
  - infusion of tissue with nanoparticles
  - verification of drug delivery to tissue targets
- Sensors/actuators – embedded nanoparticles



Schematic of equipment arrangement for the RDF-AFUM

For More Information

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

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LAR-17440-1

Vol 1, Issue 5
NP-2008-04-77-LaRC